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INTERDISCIPLINARY APPLICATIONS AND INTERPRETATIONS OF ERTS DATA WITHIN THE SUSQUEHANNA RIVER BASIN

Resource Inventory, Land Use, and Pollution

Office for Remote Sensing of Earth Resources (ORSER)
Space Science and Engineering Laboratory (SSEL)
219 Electrical Engineering West
The Pennsylvania State University
University Park, Pennsylvania 16802

Type II Report for period 1 June 1973 - 30 November 1973
Contract NAS 5-23133
ERTS Investigation 082
Principal Investigators: G. J. McMurtry and G. W. Petersen
1082AA (UN159)

Prepared for
GODDARD SPACE FLIGHT CENTER
Greenbelt, Maryland 20771

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16. Abstract

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ORSER staff members attended the ERTS-1 Investigation Status Conference at GSFC in October, giving two presentations. Several ORSER staff members have given presentations at conferences and short courses. ORSER's contacts with the international research community are growing and interest in ORSER activities is increasing among educational and governmental agencies throughout the United States.

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PREFACE

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CONTENTS

I. PROGRESS ON TASKS

Inventory of Natural Resources and Land Use

A forest type analysis is being conducted in The Pennsylvania State University Experimental Forest at Stone Valley, an area of approximately 1,800 ha. This site includes small plantings of various coniferous types, as well as several natural forest communities. The area, represented on ERTS scenes 1045-15243 (6 Sep 72) and 1171-15245 (10 Jan 73), offers a wide range of forest targets of sizes down to the resolution of the data elements obtained from the ERTS multispectral scanner.

Vegetative signatures and maps generated by computer processing with the basic ORSER programs have been compared with field notes obtained from a reconnaissance survey in July, resulting in refinement and delineation of the vegetative types in the study area. This comparison was made by using the LMAP program on the CalComp plotter to convert the best computer output into a line map reduced in scale to coincide with USGS 7 1/2 minute quadrangle maps. It was then possible to superimpose on this map all road and drainage systems in the study area. A set of random numbers was then generated to locate 40 points for investigation in the field study. These points were located by reference to nearby streams, roads, or powerlines, and field checked. Highly precise location of the points was not required due to the resolution limitations of ERTS imagery. The dominant vegetation type at each point was recorded, as well as the vegetation encountered along access routes to each point. Of all 40 points located, only one did not check with the classification on the line map. Further progress in classification of this area from ERTS data may be possible when C130 data becomes available for use as ground truth.

Land use classification of agricultural areas is being studied from several vantage points. In Pennsylvania, work is being conducted in Jefferson County and in Lancaster County.

In Jefferson County, ERTS scene 1244-15305 is being mapped, with categories to date including forest vegetation, bare soil, crops, strip mine spoils, and wet land. An attempt has been made to map "wet land" as defined by the SCS; however, it has not been possible to define a unique signature for this category.

In Lancaster County, ERTS scene 1080-15185, the following categories have been mapped: several forest categories, several water categories, a limestone quarry, bare soil, pasture land, and field with crop residues.

In mapping the above two areas, it has become evident that there are problems in classifying fields. Agricultural fields in much of Pennsylvania tend to be small, irregular in shape, and contoured with narrow strips of two or more crops. It was felt that these characteristics were a major source of difficulty in signature development and classification of agricultural land in Lancaster and Jefferson Counties. In order to be sure that it was indeed these geographical and topographical features which were the source of difficulty and not some problem in the software

algorithms, it was decided to map two areas which had large, flat, regular agricultural fields. The areas chosen were in Texas and Montana, and the preliminary results appear to confirm that the ORSER programs are operating satisfactorily, and the land characteristics in Pennsylvania are the principal cause of difficulty.

A study of land use mapping of 900 square miles in Hill County, Montana, was completed. Supervised and unsupervised classifiers were used on CCT data from ERTS scene 1052-17452, from September 13, 1972. The following classifications were made: summer fallow (5 signatures), stubble (4 signatures), water (5 signatures), vegetation (1 signature), range and prairie (2 signatures), eroded areas (1 signature), and creeks (1 signature). Copies of the report resulting from this study were sent to the ASCS in Hill County, Montana; to the Statistical Reporting Service of the Department of Agriculture, in Washington, D.C.; and to the Agronomy Department of Montana State University.

An initial analysis of an area in Hidalgo County, Texas (ERTS scene 1146-16323) has been made. Signatures for agronomic crops, bare soils, and water bodies have been established. Work is progressing on signatures for range land and cultivated pasture.

A master's thesis, "Comparison of Laboratory and Multispectral Scanner Derived Spectral Signatures for Mapping Soils," was completed by George May. The MSS data used were flown for Harold Rib of the Federal Highway Administration, by aircraft operated by the Willow Run Lab at the University of Michigan. ORSER programs were used to classify the data and produce a thematic map for three soil types. Soil samples from the area were then collected and a computer program was developed to determine the scan line and element number of these sampling locations. The samples were analyzed on a spectrophotometer and the resultant soil spectral signatures were corrected for atmospheric attenuation and solar radiation at the time the MSS data were collected. The corrected laboratory data were then used to map the three soils, using the same method applied to the MSS data. Comparison of the two maps resulted in the following conclusions:

1. It was possible to accurately assign a scan line and element number from the MSS data to each sampling location.

2. Using 12 channels in each case and critical angles for the laboratory-derived signatures of three times those used for the MSS signatures, it was possible to produce 90% agreement between each of the two signature sets for maps of three soil sites.

3. For both the laboratory-derived and the MSS signatures, it was possible to accurately map a siltstone-derived soil and differentiate it from the other two soils. However, the remaining two soils could not be adequately separated, as they were both shaley in character (one was formed from shale and the other from a shaley limestone).

4. In the cases of both the laboratory and the MSS data, signatures derived from only seven channels (3,4,5,7,9,10, and 11) yielded approximately the same results as those derived from 12 channels.

5. Subdivisions in channels 12 (1.0 to 1.4 μm) and 13 (2.0-216 μm) would enhance the spectral differences of soils and facilitate classification separations.

Using the Penn State ORSER digital processing system, digital data from ERTS scenes 1350-15183 and 1350-15190 of July 8, 1973, were processed and areas of gypsy moth defoliation were readily classified. The imagery and available ground truth were used to locate the general area of defoliation on the computer compatible tapes and to verify the computer results. Greater resolution and more detailed analysis is possible using the digital results. The extent of defoliation is shown in detail on computer output maps, while the amount of area affected is calculated and automatically produced as a quantized output.

Signatures developed in the East Branch site of the Allegheny National Forest (ERTS scene 1028-15295, 20 August 1972) were used to map an area near the Kinzua dam (same scene) with good results. All gross features (e.g., tree categories, aspect) correlated well with aircraft ground truth. There is still some problem with differentiating clouds.

Geology and Hydrology

An ERTS mosaic of Pennsylvania has been assembled for use in lineament analysis. Some of these lineaments will be compared to the known distribution of ore deposits. The scenes used for this mosaic, all from channel 7, were as follows:

Date	ID	Date	ID
20 Aug 72	1028-15293	7 Sep 72	1046-15301
21 Aug 72	1029-15352	10 Oct 72	1079-15124
21 Aug 72	1029-15354	10 Oct 72	1079-15131
6 Sep 72	1045-15240	11 Oct 72	1080-15183
6 Sep 72	1045-15243	11 Oct 72	1080-15185
7 Sep 72	1046-15295		

Negatives made from the 9 X 9 inch positive transparencies will be used to produce prints on a scale of approximately 1:250,000. It is planned to transfer the lineaments plotted on these prints, using a Saltzman projector, to a 1:250,000 base map, along with the major geological and tectonic elements in Pennsylvania. Selected portions of scene 1116-15192 (16 Nov 72) in band 7, enlarged to 1:250,000, have been used in a preliminary study of operator variability in locating lineaments.

Ground follow-up and field characterization of lineaments has been initiated. Lineaments and fracture traces are being mapped on all scales; these features are being characterized in the field and in underground operations; and theoretical models of fracturing in the crust are being developed.

In central Pennsylvania, a study has been made of the relationship among long lineaments (mapped on enlargements of channel 5 and 7 ERTS images at a scale of 1:250,000 -- scene 1116-15192, 16 Nov 72), shorter fracture traces (mapped on USDA aerial photograph AQG-4DD-80 at a scale of 1:20,000), and ground water movement and localization. It has been found that most lineaments are not distinguishable by orientation, position or density on aerial photographs, even though their position is known with reasonable accuracy from aligned water gaps. The depth dimension of fracture traces has been demonstrated by the geometric correlation found between fracture traces mapped on the surface and water-rich and/or highly jointed zones in several underground coal mines.

A site has been selected east of Tyrone for a magnetometer survey across the Tyrone-Mount Union lineament, and a proton resonance magnetometer on loan from the Smithsonian Institute has been calibrated and prepared for operation.

Cross-correlation for geologic features is continuing among the following data types: printouts of computer-processed MSS digital data from ERTS tapes, enlarged ERTS MSS images, C130 aircraft photography, and the geologic map of the Great Valley east of Harrisburg (ERTS scene 1080-15185, 11 October 1972; and U2 flight 73-009, Flight line 0-P). A photogeologic interpretation of the Pittsburgh area, using enlargements of ERTS MSS images, is being made, with the emphasis placed on mapping and characterization of linear features. Initial results indicate that only large bedrock and structural features, manifest by changes in tone, vegetation, or land use, are directly interpretable.

A geographically well-mapped glaciated area in northwestern Pennsylvania for which there is adequate cloud-free ERTS coverage, aircraft data (U.S. Dept. of Agriculture photographs at a scale of 1:20,000), and suitable topographic maps (7 1/2 min) with a forest overlay has been selected. Locally, detailed glacial geologic maps are available, as well as regional maps of all of northwestern Pennsylvania. It is not known to what extent glacial deposits of the same or of different ages can be distinguished using ERTS data and the digital processing techniques developed by ORSER. It is hoped that contrasting materials, such as sand and gravel versus till and clay, can be located, for the former type of deposits have economic potential as an aggregate source and as underground water aquifers.

Work has been started on the characterization of features associated with the Wisconsin and Illinois ice sheets. Photointerpretation and digital analysis techniques will be used. The features to be determined include deposits of glacial drift composed of till, lacustrine silt and clay, outwash sand and gravel, alluvial fans, colluvium, beach deposits, swamp deposits, and glacially eroded scours and valleys. Eleven cloud-free

ERTS scenes of northwestern Pennsylvania have been reviewed for their suitability for this study, and subsets of data have been made from four tapes from two of the scenes (1029-15354 of 21 Aug 72, and 1226-15305 of 6 Mar 73).

Mr. Krohn returned in November from temporary duty with the Pennsylvania Geologic Survey. Part of his study for the Survey involved tracking down and locating sulfide mineral occurrences in the central Pennsylvanian region. He is planning a field study of lineaments located on ERTS imagery.

Mr. Kowalik, who spent the summer working for the EROS Program in Reston, Virginia, is being trained to use the Remote Job Entry terminal in preparation for handling both ERTS and Skylab data.

An M.S. thesis on, "Hydrogeological Influences in Preventive Control of Mine Drainage from Deep Coal Mining," by John Gunnett, has been completed. This study involved fracture trace mapping on aircraft imagery in the Lecontes Mills area of Clearfield County, Pennsylvania, and correlation of these with fractured and water zones in an underground coal mine.

ERTS imagery has been used in a study of the origin of residual kaolins. An abstract of this study is appended along with an abstract of the above thesis.

Environmental Quality

The Palmerton area, in Pennsylvania, was visited on July 8, 1973, to determine: 1) the occurrence and status of vegetative damage in the vicinity of Palmerton, 2) the present state of decline of the white pine stand that was designated as a training site, and 3) by field survey, if there were other areas which could provide suitable training sites.

The vegetation within a one-mile radius of the zinc smelter was found to be in a serious state of decline. Twenty-five percent of the white pine trees in the stand were dead and none of the trees appeared to be in a "healthy" state of vigor. Although the decline of the vegetation is attributed to hydrogen sulfide, there was no apparent damage to the current year's vegetative growth.

Two additional sites were found that may possibly be used as training areas for the ERTS data. They are: 1) bare soil areas believed denuded of vegetation because of possible high zinc toxicity, and 2) areas adjacent to the bare soil plots which are supporting only black gum, sassafras, and a few red pines as a result of local pollutants.

It was also noted that a culm pile approximately one mile in length, along the northeast end of the smelter site, was visible on the channel 7 black and white transparency (ERTS scene 1116-15192, 16 November 1972).

A field survey of the Palmerton area was conducted on August 18th to determine the current severity of vegetative damage. It was observed that significant fumigations had occurred since the July 8th visitation and that damage was evident to broadleaved decidious as well as coniferous species. Sassafras trees displayed an interveinal necrosis and white and red pines exhibited a chlorotic mottle on the current year's foliage.

Requested aircraft flights of the Palmerton area were flown on September 11 (NASA Wallops C54, Mission 227-4, Flight lines 2 and 3). Another field survey was therefore made of the area on September 15, 16, and 17 to classify visible damage apparent to the white pine stand under investigation at the time of the aircraft flight. A classification system based upon needle length, retention and necrosis, and the overall color of the trees was utilized to document the condition of the foliage. The results of this classification were to be used to determine if similar severity classes could be determined from the color infrared photos taken on September 11th.

The underflight coverage provided, however, was found to be inadequate for determining damage classes for the vegetation on the selected study site. Only one of the requested three flight lines was received. This one flight line of the area missed portions of the white pine stand designated to be the primary target area and those portions which were covered were shrouded by cloud shadows. It is anticipated that the photos may, however, be helpful in processing the ERTS digital data.

Familiarization of the system and procedure for processing the ERTS tapes was obtained by mapping the Palmerton area. Digital or character maps of the region were obtained to delineate the area into four categories: forest, water, dark (shadowed) areas surrounding Palmerton, and areas defoliated by gypsy moths. The water and forested areas were found to be accurately mapped. The accuracy of the delineated areas has yet, however, to be verified. The mile long culm pile noted in the June-July report was mapped, although it was classified within the water category.

The sites affected by air pollutants were found not to be large or uniform enough to produce training sites and corresponding spectral signatures as of this reporting period. A cluster analysis is presently being utilized in an attempt to map the air pollution affected areas.

Data Processing and Pattern Recognition

The arrival of the Bausch and Lomb Zoom Transferscope has provided the opportunity to cross-correlate photographs and base maps with maps produced by photo-interpretive procedures and with computer-generated thematic maps. The approximate scale of the computer-generated map is 1:24,000. This scale is not uniform, however, because of distortion due to the printer line and element proportions. This distortion is completely overcome by the stretch capability of the transferscope. Because the transferscope has a magnification capability of 1 to 7X or 2 to 14X, depending on the lens used, it becomes possible to directly compare ERTS images, at a scale of 1:1,000,000 with computer thematic maps Xerox-reduced to 1:96,000. Studies of this combination, however, are quite limited, due to the limited area coverage of computer output (even when mosaicked) with respect to the ERTS image. We are proceeding, therefore, to study comparisons of ERTS images enlarged to a scale of 1:500,000 and computer output reduced to 1:48,000. This combination seems to be an improvement, but the results are not yet conclusive. Future plans include a study of an area using winter and spring images in the interpretation of water features and soil signatures. Aircraft data, both photographic and in the form of MSS tapes, of a chosen area will also be explored.

II. RELATED ACTIVITIES

Research

Dr. Petersen visited the University of Wisconsin, where he discussed using remote sensing for a land use and water quality study of the Great Lakes region. These discussions were held with Dr. Gordon Chesters, Director of the Water Resources Center, and Dr. James Clapp, Director of the Environmental Monitoring and Data Acquisition Group, both of the University of Wisconsin. It was suggested that Dr. Petersen consider investigating computer processing of ERTS data to delineate land cover types with a view toward relating these cover types to water quality. Dr. Petersen will be spending his sabbatical leave during the next academic year with the Water Resources Center at the University of Wisconsin, concerning himself with methods of applying remote sensing technology to the needs of private, state, and federal organizations.

A pilot study of land use mapping in the vicinity of Lake Erie has been completed for the EPA in an effort to determine if it was feasible to map the Great Lakes Basin using ERTS data. The results of this study are being reviewed by the EPA.

A contract is being negotiated with the Environmental Branch of the U.S. Army Corps of Engineers, in Washington, D.C., for mapping floodplains on the West Branch of the Susquehanna River. Lt. Scott Sollers, of the Planning Division, Civil Works Directorate, visited ORSER on 4 June to discuss the project. Aircraft photography and thermal IR imagery were flown over the West Branch of the Susquehanna during the month of June. Field data was collected simultaneously with the thermal IR flight.

Conferences

The ERTS-1 Investigation Status Conference, Goddard Space Flight Center, Washington, D.C., was attended by five ORSER staff members on October 30, 1973. Presentations were given to the Environmental Panel and the Interpretation Techniques Panel. Both panels were given descriptions of aircraft data supplied by NASA and ground truth data available to ORSER. ORSER cooperation with government agencies was described, and a cost benefit analysis given.

Results were presented to the Environmental Panel, with color slides, in the following fields.

geology and hydrology;

inventory of natural resources and land use (land use mapping, agricultural land use mapping, survey of forest resources, and vegetative cover types); environmental quality (strip mines and acid mine drainage, mapping of anthracite refuse, and insect damage to vegetation)

Using illustrations from several research projects, the three forms of ORSER interpretative techniques were described for the Interpretative Techniques Panel:

image interpretation, using photointerpretive techniques;

MSS data processing, including a demonstration of the graphics CRT remote terminal operated from a standard telephone hookup with the Computation Center at Penn State;

the hybrid approach to interpretation, in which photo-interpretation and data processing techniques are combined to maximum advantage.

Two additional topics discussed were:

MSS data banding corrections and their extention in classification, and

augmenting ERTS-1 MSS data with digitized ground truth map data.

Dr. Parizek gave a presentation, "Prevention of Mine Drainage," to the 45th Annual Conference of the Water Pollution Control Associates of Pennsylvania. The conference was attended by approximately 150 people, such as engineers, public regulatory officials, representatives from the Pennsylvania Department of Environmental Resources and the Environmental Protection Agency, and coal mine operators. Lineament mapping on ERTS and Skylab images and fracture trace mapping on aircraft photography were discussed as a means of locating connector de-watering wells to reduce ground water leakage to underlying mines. These mappable features on remote sensing images can also be a key to location of zones of potential mine roof instability and blow-out zones, which can result when mines are flooded above stream grade in an attempt to abate acid mine drainage.

The significance of gravity wells and their location at lineament intersections was stressed because these sites should both increase the efficiency of de-watering wells and at the same time increase the efficiency of recharge wells used in the gravity or connector well abatement procedure.

Dr. Parizek also attended the Pennrose Conference on Carbonate Rocks, held in Vail, Colorado, by the Geological Society of America. At this conference he presented a talk, "Hydrology of Carbonate Rocks in Humid Regions," in which he discussed new research on lineaments and fracture traces involving the use of ERTS and Skylab data. This conference was attended by 80 invited people.

The American Society of Agronomy Meetings in Las Vegas, Nevada, were attended by Dr. Petersen and George May. Mr. May gave a paper entitled, "Comparison of Laboratory Derived Signatures and Multispectrally Derived Signatures for Mapping Soils." This paper will be issued as an ORSER-SSEL technical report.

International Contacts

Dr. Pennypacker hosted representatives from six different countries, describing the ORSER program to them and discussing the use of remote sensing techniques in plant pathology studies.

1. From the Netherlands: Dr. J. C. Zadocks, Dean of the Agricultural University in Wageningen

2. From Israel: Dr. Yigal Cohen, Department of Life Sciences, Bar-Ilan University, Ramat Gan; and Dr. J. Rotem, Volcani Center, Agricultural Research Organization, Bet Dagen

3. From India: Dr. S. Nagarajan, Department of Botany, University of Delhi. Dr. Nagarajan's interest is in predicting the occurrence of wheat rust in India from remote sensing data.

4. From Germany: Dr. Manfred Mugk, Tropeninstitut, abt. Phy[illegible]-pathologie und Entomologie, Justus Liebig - Universitat.

5. From Canada: Dr. W. Cline James, Canadian Department of Agriculture, Ottawa Research Station, Ontario. Dr. Cline's interest lies in plant disease detection and crop loss analysis. He expressed interest in our program and facilities.

6. From South Africa: Dr. J. E. von der Plank, Chief of the Plant Protection Research Institute of Pretoria. Dr. von der Plank's chief interest is in Epidemiology and quantification of plant disease data.

Tapes of our programs were sent to the Delegation of the European Commission (Italian Embassy, Washington D.C. Discussions were held with representatives of UNICEF concerning the possibility of ORSER assisting UNICEF in land use mapping of an area in India.

Domestic Contacts

Capt. Paul Weitz, USN, graduate of Penn State and Skylab Astronaut, visited ORSER on September 27. He gave a seminar and slide show on Skylab, and answered a host of questions from students and staff.

Dr. Jack Crelling, Research Geologist with Bethlehem Steel Corporation (and a former graduate of Penn State) visited ORSER to discuss methods for obtaining ERTS images suitable for coal exploration work, and possible use of the Bausch and Lomb transferscope in the interpretation of these images.

Mr. Howard Heydt, Consulting Engineer for General Electric Corp., King of Prussia, Pa., visited us during this period to discuss ORSER use of the Image 100 system developed by GE.

Mr. Gerald Welsh, from the SCS in Washington, visited ORSER with a representative of the Great Lakes Basin Commission to discuss the use of remote sensing data by the Great Lakes Basin Commission for land use mapping and water quality studies of a drainage basin.

Various governmental and private agencies have shown interest in ORSER facilities during this period. For example:

1) Two geologists from the Pennsylvania Geologic Survey obtained Ozalid prints of several ERTS scenes. They were interested in mapping ore deposits using ERTS images.

2) Two representatives of the Cartographic Division of the SCS in Hyattsville, Maryland, were shown our facilities.

3) Seven representatives from the SCS office and two from the NE Economic and Development Council in Avoca, Pennsylvania, were shown our facilities and program.

Tapes of our programs were sent to the Department of Mathematics, Texas Technological College, Lubbock, and a second (revised) set of tapes of our programs was sent to the USDA in Washington, D.C. Batelle Institute in Columbus, Ohio, requested and received a complete set of ORSER technical reports.

Education

Dr. Parizek participated in the U.S. Department of Agriculture Extension Training Program in Water and Environmental Resources Management held at Penn State. The conference, titled "Water Management, Environmental Resources Management" (Agronomy 490), was attended by 50 people. Parizek presented the talk, "Ground Water Resources of Pennsylvania, An Overview: What, Where, When, and How Much." ERTS, Skylab, and aircraft images were used to illustrate the use of lineaments and fracture traces in prospecting for water. The possible use of remote sensing data for monitoring well locations was discussed.

Approximately 70 people attended a short course at Penn State on "Controlling Water Pollution in Coal Mining: Biological-Hydrological Influences on Mine Drainage Control." Dr. Parizek participated in this course, presenting material from ERTS, Skylab, and aircraft sources, and indicating how lineaments and fracture traces plotted on these images could be used t locate sites for drilling mine dewatering wells. The significance of gravity wells and their location at lineament intersections was stressed because these sites should increase the efficiency of dewate ing wells while increasing the efficiency of recharge wells used in the gravity or connector well abatement procedure.

Dr. McMurtry presented a talk entitled, "Introduction to Remote Sensing and ERTS," to an undergraduate course in Community Development. Don Henninger gave a lecture in a graduate level Architecture course in Computer Graphics, entitled, "Analysis of Remote Sensing Data as Applied to Updating Land Use Plans."

Other Activities

Dr. Gold was on a lecture tour of southern Africa, where he delivered six lectures on "Sputnik to Skylab," which included a review of the ERTS program. He also visited the U.N. geological team working on remote sensing techniques for lineament and fracture trace analyses of Lesotho.

Dr. McMurtry gave a talk to the Harris Township Lions Club of Centre County, Pennsylvania, on "Pictures from Above."

Drs. Turner and Petersen attended the Remote Sensing Meetings in Sioux Falls. They did not give any papers.

Dr. Weeden presented a talk to the Luzerne County Chapter of the Pennsylvania Society of Prefessional Engineers entitled, "The Office for Remote Sensing of Earth Resources at The Pennsylvania State University."

Pattee Library at Penn State, is eager to have our reports deposited in their library system. Arrangements were made to send a copy to the Library each time one is issued.

III. REPORTS

ORSER-SSEL Technical Report 10-73, "Program Descriptions" has been issued. This report represents an abridgement of our "... Data Users Manual," (see below) in that it contains somewhat abridged versions of the program descriptions and does not include individual card descriptions or specific instructions for using the programs.

ORSER has completed ORSER-SSEL Technical Report 11-73, "ERTS and Aircraft Multispectral Scanner Digital Data Users Manual," describing in detail all ORSER programs to date with specific card descriptions and instructions for use. Other reports in process describing ORSER data handling and processing procedures are as follows:

STORAGE AND RETRIEVAL OF ERTS AND UNDERFLIGHT IMAGERY

DEVELOPMENT OF THE HYBRID APPROACH TO DATA PROCESSING

CATALOGUES FOR REMOTE SENSING DIGITAL DATA TAPES

PROCESSING OF REMOTE SENSING DATA

CORRECTION OF BANDING IN MSS DIGITAL DATA

ANALOG TO DIGITAL CONVERSION AND PROCESSING OF MSS DATA USING A HYBRID COMPUTER

Several research reports are also in the last stages of completion. These are:

LAND USE MAPPING

COMPARISON OF PREPROCESSING AND CLASSIFICATION TECHNIQUES AS APPLIED TO MULTISPECTRAL SCANNER DATA

SURVEY AND INVENTORY OF FOREST RESOURCES

CANONICAL ANALYSIS APPLIED TO THE INTERPRETATION OF MULTI-SPECTRAL SCANNER DATA

MAPPING OF ANTHRACITE REFUSE

INVESTIGATION OF VEGETATIVE COVER CONDITIONS

ACID MINE DRAINAGE

AGRICULTURAL LAND USE MAPPING

The essence of most of these reports was covered in various chapters of our Type II Report for June 1, 1972 through May 30, 1973. However, it has appeared desirable to issue these as separate reports for dissemination to interested parties, and in several cases these have been updated from work done since May 30

IV. DATA REQUESTS, FLIGHTS, AND RECEIPTS

The following data flights were made during this reporting period:

6 August	Mission 247	C130
13 August	Mission 227-1	C54
11 September	Mission 227-4	C54
10 August	Mission 238	RB57
29-31 August	Mission 238	RB57
19 October	Mission 227-5	RB54

The following data were received during this reporting period (other than routine ERTS images and tapes):

Mission 194 (C54)	photography
Mission 227-1 (C54)	photography
Mission 227-4 (C54)	photography
Mission 227-5 (C54)	photography
Mission 73-009 (U2)	MSS imagery
Mission 230 (C130)	MSS data tapes

APPENDIX A

ABSTRACT

HYDROGEOLOGICAL INFLUENCES IN PREVENTIVE CONTROL OF MINE DRAINAGE FROM DEEP COAL MINING

John W. Gunnett

(M.S. Thesis in Mining Engineering, December 1973)

Drainage from coal mines is a major stream pollutant. Treatment of mine drainage has been the practical means of combating this degradation of surface waters; however, preventive control remains as the realistic solution. The objectives of this study were to evaluate major avenues for ground water infiltration into deep mine environments, and to interpret relationships between geological, hydrological, chemical and mining method parameters in terms of practical actions which will lead to amelioration of existing, and prevent future deleterious, mine drainage conditions.

The study entailed investigation of these parameters relating to an active deep coal mine. Included in these investigations were considerations of fracture traces, surface and underground jointing, and quality of water samples collected at various locations within the study mine.

For this mining environment, it was found that the major source of infiltration is the caved areas, and that jointing associated with surface fracture traces is the primary infiltration route in uncaved portions of the mine. Further, mine waters are subject to degradation while draining to sumps, and during retention in pools. These data indicate that certain techniques applied to divert ground water flow in conjunction with changes in procedures for handling drainage within mine should result in a significant reduction in the water quantity, as well as improvement in the quality of mine drainage.

APPENDIX B

ABSTRACT

ORSER-SSEL Technical Report 26-74

APPLICATION OF ERTS IMAGERY TO THE STUDY OF RESIDUAL KAOLINS

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ERTS imagery was employed to investigate the possibility of correlation of clay deposits in the Gatesburg formation of central Pennsylvania with linear features. Twenty-two clay occurrences were mapped on 7 1/2 minute quadrangle maps from Bedford to Lamar, and lineaments were transferred from two ERTS images (1045-15243 and 1243-15253) to these maps. Only two of the clay occurrences were found on lineaments. In a smaller study, using aircraft photography, it was found that there was no correlation between the occurrence of clay deposits and the location of fracture traces.

It is concluded that factors such as bed attitudes, initial rock porosity, and local topography were more influential in enhancing percolation and concentrating clay deposits than was fracturing manifest as fracture traces and lineaments.